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Harvestman assemblages (Arachnida: Opiliones) in Krkonoše National Park

Společenstva sekáčů (Arachnida: Opiliones) v Krkonošském národním parku

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Abstract. Harvestmen were collected in 13 localities of Krkonoše National Park from 1988 to 1991 using pitfall traps. Altogether 9106 individuals belonging to ten species were captured. Among them *Ischyropsalis hellwigi hellwigi* (Panzer, 1794) and *Nemastoma triste* (C. L. Koch, 1835) are the most interesting finds, rarely reported from the Czech Republic. Canonical correspondence analysis of the harvestman assemblages showed little differentiation between individual assemblages, except for those in the alpine zone, where species richness sharply declined and only *Mitopus morio* (Fabricius, 1799) and *Platybunus bucephalus* (C. L. Koch, 1835) remained abundant. The effect of the herbicide Roundup on the number of opilionid taxa and specimens was non-significant. However, the abundance of *Oligolophus tridens* (C. Koch, 1836) was higher in the traps located in the treated *Rumex alpinus* stand.

INTRODUCTION

Harvestmen in Krkonoše National Park belong to a species-poor group. However, their abundance is high along the whole altitudinal gradient, in forests as well as on meadows, and also in human settlements. In spite of the ubiquity of harvestmen little attention has been paid to their taxonomic representation in the Krkonoše Mountains. The first records are from the verge of the century when Nosek (1900) published a key for harvestmen of Bohemia and Moravia. His findings of "*Egaenus* C. L. Koch *tibialis* (?)" (= *E. convexus* (C. L. Koch, 1835)) and *Phalangium propinquum* Lucas, 1846 (see also Nosek 1906) are doubtful and were already questioned by Kratochvíl (1934). Besides, Nosek (1900) called *Platybunus bucephalus* (C. L. Koch, 1835) a common species in the Krkonoše Mountains. The survey of harvestmen by Kratochvíl (1934) included six species collected in the Krkonoše Mountains (*Nemastoma lugubre* (O. F. Müller, 1776) – melanistic variant, *Platybunus bucephalus, Gyas annulatus* (Olivier, 1791) and the above-mentioned *Egaenus tibialis*). The records of *Nemastoma triste* (C. L. Koch, 1835) (in Poland only?) and *Ischyropsalis hellwigi hellwigi* (Panzer, 1794) from the Sudeten Mountains may refer to the Krkonoše Mountains, too. Later the record of *Gyas annulatus* was proved to belong to *Gyas titanus* Simon, 1879 (Martens 1978). Šilhavý (1970) presented findings by L. Vysloužil from 1961–1967, including *Ischyropsalis hellwigi* in the Obří Důl Valley, *Leiobunum rupestre* (Herbst, 1799) in the Rýchory Range, *Mitopus morio* (Fabricius, 1799) on Liščí and Černá hora Mounts, near the Luční bouda chalet and in the Rýchory Range, and *Platybunus bucephalus* on Liščí and Černá hora Mounts and the Luční bouda chalet. Šilhavý (1981) published a distribution map of *Leiobunum rupestre* in the Czech Republic which includes

localities in the Krkonoše Mountains. Růžička & Zacharda (1994) studied arthropods, including harvestmen, in stony debris in several localities of the Krkonoše Mountains. They recorded *Mitopus morio* and *Platybunus bucephalus* only. Finally, there are several popular treatises, such as Buchar et al. (1983), Černý & Doskočil (1969) and Obenberger (1952), in which some of the above-mentioned species are reported without localities. A more complete picture of the occurrence of harvestmen is available for the Polish side of the Krkonoše Mountains, summarised by Rafalski (1961) and Starega (1975).

So far no attention has been paid to harvestman assemblages in the Krkonoše Mountains, to their species composition and the differentiation between various types of environment. In this paper results are presented based on pitfall trapping in 13 localities. The aim of the paper is to describe the species composition of harvestman assemblages in various types of habitats, ranging from spruce forests and mountain meadows in clearings up to peat bogs above the tree line and an alpine tundra.

LOCALITIES AND METHODS

From 1988 to 1991 thirteen localities between 760 and 1550 m a. s. l. were selected in the Krkonoše Mountains by K. Tajovský and his collaborators from the Institute of Soil Biology, České Budějovice (see Balík 1992, Háněl 1994 and Starý 1994 for details):

1. Třídomí settlement: regularly managed spruce forest, partly damaged by emissions, with ferns dominating in the herb layer, 760 m a. s. l. (Háněl 1994). 15°32.5'W, 50°43.5'N.
2. V bažinkách protected area: NE slope of the Kozelský crest, a pristine beech and spruce forest with *Abies alba* and *Acer pseudoplatanus*. In the herb layer the following herbs were recorded: *Homogyne alpina*, *Gentiana asclepiadea*, *Athyrium distentifolium*, *Prenanthes purpurea*, etc. 830 – 1100 m a. s. l. (Balík 1992). 15°32'W, 50°44'N.
3. Pod bažinkami locality: herbaceous plant community close to a stream; the stand is close to the locality "V bažinkách", c. 900 m a. s. l. 15°32'W, 50°44'N.
4. Pančavská louka peat bog: 1330 m a. s. l. 15°32.5'W, 50°46'N.
5. Úpská peat bog: with rich moss layer dominated by *Sphagnum* sp. div., *Carex rostrata* in the herbaceous and *Pinus mugo* in the shrub layer, 1420 – 1425 m a. s. l. (Balík 1992). 15°43'W, 50°44.5'N.
6. Studniční hora Mount: c. 200 m north of the top, alpine tundra, 1554 m a. s. l. (Balík 1992). 15°44'W, 50°42'N.
7. Zadní Rennerovky settlement: species-rich meadow dominated by *Nardus stricta,* 1280 m a. s. l. (Háněl 1994). 15°40'W, 50°42'N.
8. Přední Rennerovky settlement (A): clearing, until recently a damaged forest, dominated by *Calamagrostis villosa* in the herb layer, close to locality no. 13, 1200 m a. s. l. (Háněl 1994). 15°40'W, 50°42'N.
9. Navorská jáma cirque: upper part of the Labský důl valley, pristine spruce forest, partly damaged by emissions, with *Vaccinium myrtillus* dominating in places in the herbaceous layer, the shrub layer with a low cover, 1060 m a. s. l., (Háněl 1994). 15°33'W, 50°46'N.
10. Schustlerova zahrádka ("Schustler's garden"): located in the upper Labe valley, a glacial cirque, a locality famous for its richness of vascular plant species, 1100 m a. s. l. (Balík 1992; Tajovský, pers. comm.). 15°33'W, 50°46'N.
11. Dvoračky settlement – Roundup: stand of *Rumex alpinus* suppressed by application of the herbicide Roundup, 1120 m a. s. l. 15°31'W, 50°45'N.
12. Dvoračky settlement: mountain meadow, control plot for the treatment applied in the preceding locality, 1120 m a. s. l. 15°31'W, 50°45'N.
13. Přední Rennerovky settlement (B): damaged spruce forest close to locality no. 8. 1200 m a. s. l. 15°40'W, 50°42'N.

Locality no. 12 served as a control plot for locality no. 11 where the herbicide Roundup was applied on a *Rumex alpinus* stand. Roundup is a total plant destroying herbicide, containing glyphosate at 360 $g.l^{-1}$. It has been applied in large areas of Krkonoše National Park on *R. alpinus* stands, as this species, a nitrophilous herb colonising nutrient-rich habitats in the mountains and forming large and very species-poor stands there, is considered a weed. The permanent plots established for this experiment were 25 m^2 in size. Roundup was applied in 1985 at concentration of 10 $l.ha^{-1}$. During the next three years individual plants of *R. alpinus* which either regenerated from rhizomes or established from seed were treated with Roundup again. As a result, the original *R. alpinus* stand was replaced by other dicotyledonous plants. A year after the Roundup treatment was performed arthropod collection started. For details see Kotlaba et al. (1988) and Mládková (1992).

Table 1. The dates when pitfall traps were exposed (x) and emptied (m) in individual localities (1 to 13, see text) in the Krkonoše Mountains.
Tabulka 1. Data exponování (x) a vybírání (m) zemních pastí na jednotlivých lokalitách (1 – 13, viz text) v Krkonoších.

	Locality – lokalita												
Date – datum	1	2	3	4	5	6	7	8	9	10	11	12	13
15.–16.vi.1988	x	x		x	x	x	x	x	x	x			
21.–22.ix.1988								xm	xm				
12.–13.vi.1989	xm	xm	x	m	m	m	xm	xm	xm	xm	x	x	
26.–27.ix.1989			xm								xm	xm	
26.–27.vi.1990	xm	m	m				m	xm	xm	m	xm	xm	
18.–19.x.1990	xm							xm	xm		m	m	
18.–19.vi.1991	xm							xm	xm				x
30.–31.x.1991	m							m	m				m

In each locality 5 pitfall traps were placed along a horizontal line. The distance between individual traps was about 5 m (except for the localities 11 and 12 where the distance was shorter). The area of each of the pitfall traps was 78.5 cm^2. The traps were filled with a solution of formaldehyde (70 ml of 48% formaldehyde, 200 ml of 85% glycerol and a few drops of detergent in 1 litre of the solution). The pitfall traps were usually emptied two times a year, according to the scheme given in Table 1. In three localities pitfall traps were exposed for shorter periods, but always for at least several months.

Canonical correspondence analysis (CCA – ter Braak 1987, Jongman et al. 1995) was used to assess the role of the environmental factors (light, altitude, soil moisture, temperature and human impact, estimated according to a 5-degree ordinal scale) which were previously found as important for differentiation of harvestman assemblages – see Klimeš (1998) for details. Species abundance was log(x+1) transformed to suppress strongly dominating species.

The complete names of the harvestman species are given in Table 2 and follow Martens (1978).

RESULTS

Altogether 10 species of harvestmen were captured, and a melanistic variant of *Nemastoma lugubre* which is treated as a separate taxon here. The total number of individuals was 9106 (Tab. 2). The most abundant species was *Mitopus morio* (4336 individuals), followed by *Platybunus bucephalus* and *Oligolophus tridens* (C. Koch, 1836) (2422 and 1209 individuals, respectively). Four taxa were captured in amounts of less than 20 individuals: *Mitostoma chrysomelas*, *Nemastoma lugubre* – melanistic variant, *Ischyropsalis hellwigi hellwigi* and *Nemastoma triste*. Two species were recorded in all localities (*Mitopus morio* and *Platybunus bucephalus*). In contrast, *Ischyropsalis hellwigi hellwigi* was found in only four and *Nemastoma triste* in just one locality. The number of taxa in individual localities ranged between 2 and 10. In the Navorská jáma cirque all ten species were collected. It is very probable that the data given in Tables 2 and 3 well represent species richness and also the abundance/activity of individual species, as adults of all captured species reach the highest abundance either in autumn or are eurychronous (Šilhavý 1956, Martens 1978) and in each of the localities harvestmen were captured during at least one autumnal period.

The number of species was independent of the number of specimens ($r = 0.466$, $P > 0.05$, $df = 11$). There was a strong trend of decreasing species richness with altitude ($r = 0.652$, $P < 0.01$) with only two species recorded above 1400 m a. s. l. The highest number of species was recorded in mixed and coniferous forests up to the tree line. Most harvestman species penetrated into the alpine zone, but usually had a low abundance. The only exception was *Mitopus morio*, which reached its highest abundance in the alpine zone. The species composition of harvestman assemblages in forests and on meadows was similar. In contrast, all harvestman assemblages from

Table 2. Number of specimens of individual species of harvestmen in 13 localities of the Krkonoše Mountains captured by pitfall traps between 1988 and 1991.
Tabulka 2. Počty jedinců jednotlivých taxonů sekáčů chycených do zemních pastí na 13 lokalitách v Krkonoších (1988-1991).

		1	2	3	4	5	6	7	8	9	10	11	12	13	
		Třídomí	V bažinkách	Pod bažinkami	Pančavská louka	Úpská rašelina	Studniční hora	Zadní Rennerovky	Přední Rennerovky (A)	Navorská jáma	Schustlerova zahrádka	Dvoračky - - Roundup	Dvoračky	Přední Rennerovky (B)	Total Celkem
1	*Ischyropsalis hellwigi hellwigi* (Panzer, 1794)			2				2	2	5					11
2	*Lacinius ephippiatus* (C. L. Koch, 1835)	4	1	7				32	44	2		164	193	8	455
3	*Lophopilio palpinalis* (Herbst, 1799)	186	1	7						65		1			260
4	*Mitopus morio* (Fabricius, 1799)	496	27	61	746	156	453	443	477	590	27	410	206	244	4336
5	*Mitostoma chrysomelas* (Hermann, 1804)	1						1	13	2	1				18
6	*Nemastoma lugubre* (O. F. Müller, 1776)		2	7	1			133	71	3	2	7	11	32	269
7	*Nemastoma lugubre* (O. F.Müller, 1776) - melanistic variant	1	1					8				1	1		12
8	*Nemastoma triste* (C. L. Koch, 1835)									4					4
9	*Oligolophus tridens* (C. Koch, 1836)	116	20	120	9			193	131	34	38	188	346	14	1209
10	*Paranemastoma quadripunctatum* (Perty, 1833)	24	1	13				2	5	23	21		19	2	110
11	*Platybunus bucephalus* (C. L. Koch, 1835)	323	7	24	40	9	154	80	138	1194	46	9	14	384	2422
	No. of taxa – počet taxonů	8	8	8	4	2	2	9	8	10	6	7	7	6	11
	No. of specimens - počet jedinců	1151	60	241	796	165	607	894	881	1922	135	780	790	684	9106

the area above the tree line were markedly species-poor, no matter in which type of environment the traps were placed.

The variation in species data, explained by the first two axes of CCA was 20% and 19%, respectively. The CCA analysis showed that human impact increases with mean temperature, i.e., in localities at lower altitude, and decreased with soil moisture (Fig. 1). However, correlation of the first CCA axis with environmental factors was weak and non-significant ($P > 0.05$; unrestricted permutations, Monte Carlo tests). The CCA diagram shows that harvestman assemblages of forests and meadows located close to the tree line differed only little (Fig. 1A). Several species avoided open habitats (Fig. 1B) and there were no species preferring the alpine zone. *Lacinius ephippiatus* (C. L. Koch, 1835) showed the highest affinity to localities disturbed by human activities.

The effect of Roundup application on harvestmen was weak (Table 4). No difference was found in the number of species between the treated and control traps ($P > 0.05$). Only a single species, *Oligolophus tridens*, showed a significant difference in abundance between treated and control traps and was less abundant in the traps located in the treated plot. However, during the first period, just after the last pesticide treatment was performed, its abundance in the treated plot was higher than in the other plot. The total number of specimens captured during the two years was approximately the same on the two plots. However, *Mitopus morio* strongly preferred the Roundup plot just after the last application. Later, during the second period, the reverse was observed. The only species which was missing in traps placed in the Roundup plot was *Paranemastoma quadripunctatum* (Perty, 1833), a species living at ground level, mostly in plant litter and in the humus layer. Unfavourable changes in microclimatic conditions could explain its absence in the plot where the herbaceous layer was destroyed by the herbicide.

DISCUSSION

Most of the eleven harvestman taxa captured during this study represent species with broad ecological amplitudes. All of them are generally common in central European mountains, except for *Ischyropsalis hellwigi hellwigi,* a mountain species so far reported from a few mountain localities in the Czech Republic (Bárta 1869, 1870, Nosek 1906, Zavřel 1930a, b, Kratochvíl 1934, Bartoš 1938, Šilhavý 1956, 1958, 1970, 1972, Sechterová-Špičáková 1988, Souček 1959, Šmaha 1983, 1986, Roháček 1973, 1988, Dolanský 1997), and *Nemastoma triste*, which is less apparent and also less known than the previous species. It has been so far reported from the Šumava Mountains (Roewer 1923, Kratochvíl 1934, Bartoš 1949, Šilhavý 1956, Klimeš & Roušar 1998), Mariánské Lázně town (Šilhavý 1956, 1966), the Křivoklátsko Protected Landscape Area (Šmaha 1984, 1986, Klimeš & Roušar 1998), Krušné Hory Mountains, Broumovské stěny protected area, Kamenec Mount near the Česká Lípa town and from the Třeboň Basin (Klimeš & Roušar 1998). There is also a report on *N. triste* from the Krkonoše Mountains, however from the Polish side (Fickert 1875). Besides the Navorská jáma cirque, reported here, one more locality, near the Albrechtec settlement, has been recently found on the Czech side of the Krkonoše Mountains (Klimeš & Roušar 1998).

The harvestman assemblages studied in the Krkonoše Mountains are similar to those known from other Sudeten Mountains, such as the Jeseníky Mountains, Mt. Králický Sněžník and also

Table 3. Percentage of individual species of harvestmen in 13 localities of the Krkonoše Mountains captured by pitfall traps between 1988 and 1991 (100% corresponds to all individuals captured in a particular locality).
Tabulka 3. Procentické zastoupení jednotlivých taxonů sekáčů chycených do zemních pastí na 13 lokalitách v Krkonoších (1988-1991) (100% odpovídá celkovému počtu jedinců odchycených na dané lokalitě).

	1	2	3	4	5	6	7	8	9	10	11	12	13
	Třídomí	V bažinkách	Pod bažinkami	Pančavská louka	Úpská rašelina	Studniční hora	Zadní Rennerovky	Přední Rennerovky (A)	Navorská jáma	Schustlerova zahrádka	Dvoračky - - Roundup	Dvoračky	Přední Rennerovky (B)
1*Ischyropsalis hellwigi hellwigi* (Panzer, 1794)	0	0	0.8	0	0	0	0.2	0.2	0.3	0	0	0	0
2*Lacinius ephippiatus* (C. L. Koch, 1835)	0.3	1.7	2.9	0	0	0	3.6	5	0.1	0	21	24	1.2
3*Lophopilio palpinalis* (Herbst, 1799)	16	1.7	2.9	0	0	0	0	0	3.4	0	0.1	0	0
4*Mitopus morio* (Fabricius, 1799)	43	45	25	94	95	75	50	54	31	20	53	26	36
5*Mitostoma chrysomelas* (Hermann, 1804)	0.1	0	0	0	0	0	0.1	1.5	0.1	0.7	0	0	0
6*Nemastoma lugubre* (O. F. Müller, 1776)	0	3.3	2.9	0.1	0	0	15	8.1	0.2	1.5	0.9	1.4	4.7
7*Nemastoma lugubre* (O. F. Müller, 1776) - melanistic variant	0.1	1.7	0	0	0	0	0.9	0	0	0	0.1	0.1	0
8*Nemastoma triste* (C. L. Koch, 1835)	0	0	0	0	0	0	0	0	0.2	0	0	0	0
9*Oligolophus tridens* (C. Koch, 1836)	10	33	50	1.1	0	0	22	15	1.8	28	24	44	2
10*Paranemastoma quadripunctatum* (Perty, 1833)	2.1	1.7	5.4	0	0	0	0.2	0.6	1.2	16	0	2.4	0.3
11*Platybunus bucephalus* (C. L. Koch, 1835)	28	12	10	5	5.5	25	8.9	16	62	34	1.2	1.8	56

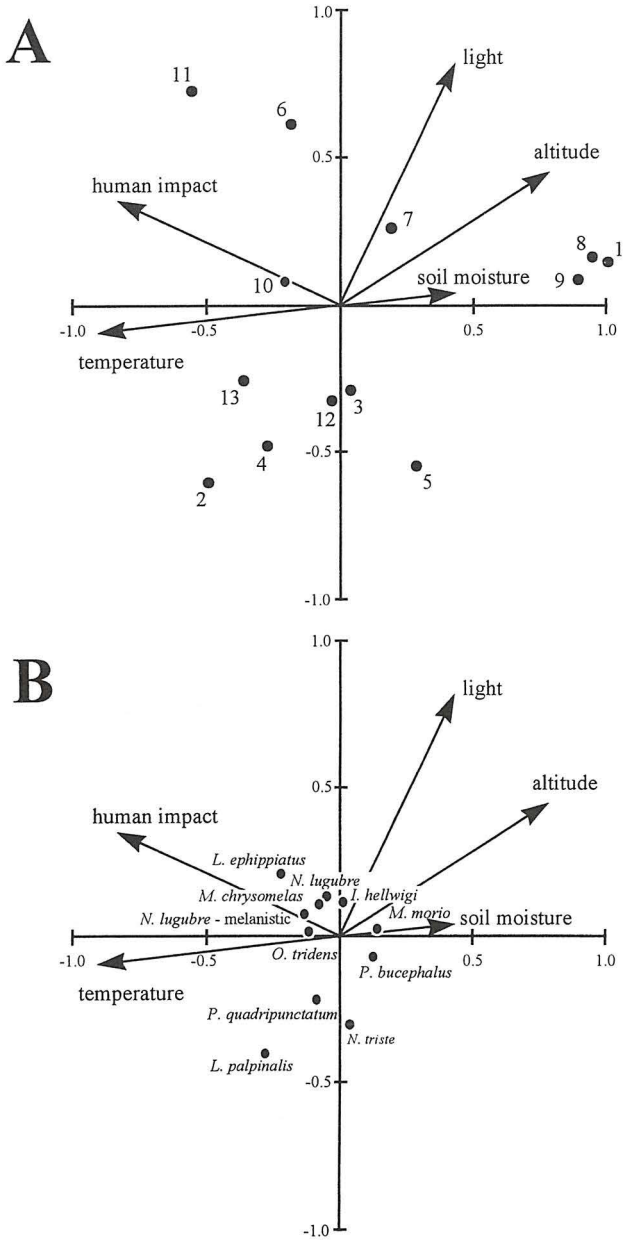

Fig. 1. Canonical correspondence analysis (CCA) of harvestman assemblages in the Krkonoše Mountains. The arrangement of localities (A) and species (B) in the diagram reflects the strength of individual environmental factors indicated by the length of the corresponding arrows.

Obr. 1. Kanonická korespondenční analýza (CCA) společenstev sekáčů v Krkonoších. Rozmístění lokalit (A) a druhů (B) v diagramu odráží vliv jednotlivých faktorů prostředí. Význam faktorů prostředí roste s délkou šipky.

Table 4. The effect of Roundup application on harvestmen assemblages at Dvoračky chalet, Krkonoše Mountains. Total number of individuals captured in 5 pitfall traps is given. Differences between treatments were tested using t-test. ns - $P > 0.05$, * - $P < 0.05$. C – the control plot (locality no. 12), R - treated with Roundup (locality no. 11).
Tabulka 4. Vliv herbicidu „Roundup" na společenstva sekáčů na lokalitě Dvoračky v Krkonoších. Je uveden celkový počet jedinců odchycených do 5 zemních pastí. Vliv zásahu byl testován pomocí t-testu. ns - $P > 0.05$, * - $P < 0.05$. C – kontrolní plocha (lokalita č. 12), R - plocha ošetřená herbicidem „Roundup" (lokalita č. 11).

	26.ix.1989		26.vi.1990		18.x.1990		Totals Celkem		Significance for totals Signifikance pro celkový počet
	C	R	C	R	C	R	C	R	
Lacinius ephippiatus	89	130	31	2	73	20	193	152	ns
Lophopilio palpinalis				1				1	ns
Mitopus morio	101	326	95	45	10	17	206	388	ns
Nemastoma lugubre		2	10	5	1		11	7	ns
Nemastoma lugubre - melan. var.			1	1			1	1	ns
Oligolophus tridens	25	41	310	141	11	2	346	184	*
Paranemastoma quadripunctatum	2		3		14		19		ns
Platybunus bucephalus	4	1	6	4	4	4	14	9	ns
No. of specimens - počet jedinců	221	500	456	199	113	43	790	742	ns
No. of taxa – počet taxonů	5	5	7	7	6	4	9	9	ns

from narrow valleys at lower elevations where cold and humid climate prevails (Klimeš 1998). There is no characteristic species distinguishing the assemblages in the Krkonoše Mountains from those reported from other mountain ranges in the Czech Republic (Klimeš 1998).

The high mobility of the long-legged harvestmen and their relatively high tolerance to environmental changes resulted in a weak response to defoliation caused by the herbicide Roundup. The temporary increase of litter and therefore also of prey abundance resulted in a high number of harvestmen captured in defoliated patches soon after the treatment. Therefore, the response of harvestmen was likely caused by changes in prey density and in changes in the amount of litter, and not by the pesticide itself. These changes were temporary and tended to diminish after two years.

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SOUHRN

Fauna sekáčů (Opiliones) byla studována na 13 lokalitách v Krkonoších pomocí zemních pastí. Bylo chyceno 10 druhů zastoupených celkem 9106 jedinci. Počet druhů na jednotlivých lokalitách byl až 10, na lokalitách nad 1400 m n. m. však byly zjištěny jen dva druhy, *Mitopus morio* a *Platybunus bucephalus*. Byl potvrzen výskyt dvou vzácných druhů sekáčů, *Nemastoma triste* a *Ischyropsalis hellwigi hellwigi*. Od fauny ostatních pohoří v českých zemích se krkonošská společenstva neliší ani druhovým složením, ani relativním zastoupeních jednotlivých druhů.

Na plochách ošetřených totálním herbicidem „Roundup" u Dvoraček byl zjištěn velmi malý vliv na sekáče. Počet druhů ani celkový počet jedinců nebyl ovlivněn. U některých druhů přechodně stoupla početnost, pouze u *Oligolophus tridens* byl počet jedinců odchycených v průběhu dvou let nižší než na kontrolní ploše.